Lifting and Overwinter Storage of White Pine in Southern Ontario

by

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Abstract

A fall lifting and overwinter storage trial on 3+0 white pine (*Pinus strobus* L.) was carried out at St. Williams forest tree nursery (42° 40'N, 80° 25'W) during two consecutive years to study: (1) the degree hardening day (DHD) requirement for lifting; and (2) the effect of different storage temperature regimes: cold (1-4° C) and frozen (-3° C) on the performance of stock stored overwinter. Field performance was best if lifting for overwinter storage was delayed until after an accumulation of 125 DHD which is less than that required farther north. In some instances, seedlings lifted very late in the year had reduced survival and growth in the following year. Seedlings were ready for cold storage before being ready for frozen storage. Frozen storage is preferred owing to molding problems associated with cold storage.

Résumé

L'essai d'une cueillette d'automne et d'un remisage hivernal pour des pins blancs (3+0 (*Pinus strobus* L.) a eu lieu à la pépinière de St Wiliams (42° 40'N, 80° 25'W) au cours de deux années consécutives afin d'étudier: 1/ le nombre de gré-jour d'aoûtement (DBD) requis pour effectuer la cueillette, et 2/ le remisage à froid (1-4° C) et la congélation (-3° C). Les meilleurs résutats ont été obtenus lorsque la cueillette pour fin de remisage hivernal fut retardée jusqu'à ce ue 125° C DHD furent accumulés, ce qui est moindre que ce qui est requis plus au nord. Dans certains cas, les semis cueillis très tard dans l'année ont connu un taux de survie et de croissance réduits l'année suivante. Les semis étaient prêts pour un remisage à froid avant d'être préparés pour la congélation. La congélation est préférable par suite desproblèmes de moisissures associés au remisage à froid.

Introduction

The success of overwinter storage of white pine (*Pinus strobus* L.) varies with lifting date and storage temperature (Mullin and Parker 1974). Lifting as late as possible in the fall has been considered one way to improve success (Williams and Rambo 1967, Mullin and Parker 1974, Nyland 1974a). However, earlier lifting is sometimes necessary to avoid freeze-up.

The degree hardening day (DHD) method was developed to determine readiness for fall lifting based upon soil temperature (Mullin and Parker 1974, 1976) and has been applied with some success to many Ontario tree species (Mullin and Hutchison 1978a, 1979, Mullin and Lucas 1982, Racey and Hutchison 1983, Racey *et al.* 1983a) including white pine (Mullin and Hutchison 1978b). However, differences in DHD requirements for white pine between nurseries (Mullin and Parker 1976, Mullin and Hutchison 1978b) indicate that DHD requirements are dependent upon climate and seed provenance.

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In Ontario frozen storage (-3° C) has generally been considered best for overwinter storage of coniferous nursery stock (Mullin and Parker 1974, 1976, Mullin and Hutchison 1978b), owing to the incidence of mold in cold (1-4° C) storage (Wilner and Vaartaja 1958, Nyland 1974b and Venn 1980, 1981). However, mold tends to be less of a problem with stock lifted late in the fall.

The purpose of this paper is to examine lifting times and storage temperatures for white pine at the St. Williams tree nursery (42° 40'N, 80° 25'W) and to compare these findings with those from other Ontario nurseries (Mullin and Parker 1974, 1976, Mullin and Hutchison 1978b) so that we can make recommendations for white pine storage in southern Ontario.

Methods

In the fall of 1977 an overwinter storage trial was begun at St. Williams Forest Tree Nursery using 3+0 white pine (site region 7E (Hills 1960)). This trial involved seven fall lifts in 1977 and four in 1978 (Fig. 1). Lifted trees were put into either cold storage (1° C at Midhurst, 2-4° C at St. Williams) or frozen storage (-3°). Trees were lifted by hand from randomized blocks laid out in a single shipping bed which was undercut

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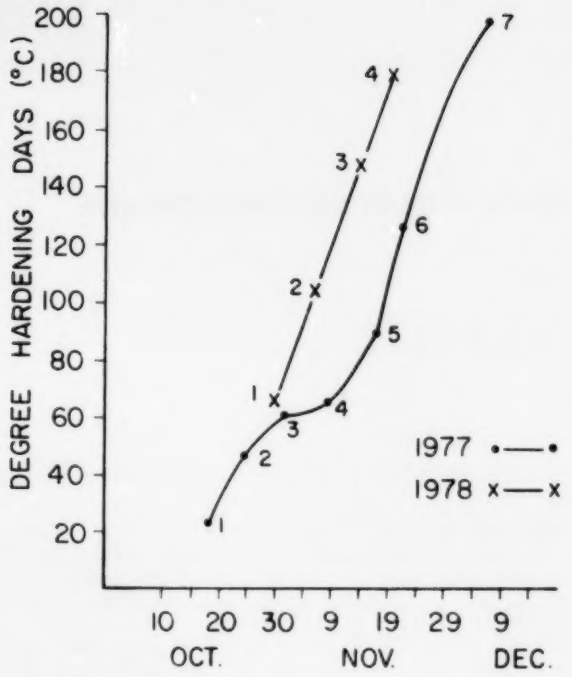

Figure 1. Date and degree hardening days (DHD) for seven fall storage lifts at St. Williams nursery in the fall of 1977 and 4 lifts in the fall of 1978. Degree hardening days were determined using a 10°C base and soil temperatures measured 15 cm below ground level. Lift numbers are depicted on the graph adjacent to the DHD line for each year.

with an Egedal blade. Seedlings were field graded and packed in Kraft bags with a polyethylene insert. A handful of damp cedar shavings, as a moisture retaining material, was added to the top and bottom of each bag. Seedling morphology was determined by measuring shoot length, stem diameter, and shoot and root dry weights on each of 25 trees from four randomly selected seedling bundles of each lifting date. The accumulated degree hardening days were calculated using a 10°C base with soil temperatures recorded at 15 cm depth (Mullin and Parker 1976).

All trees were stored in the operational refrigerated storage facilities at St. Williams nursery and at the Midhurst Research Station for the outplantings in the respective areas. Seedlings stored at Midhurst were transferred from St. Williams on the day of lifting.

Seedlings from each lifting date were outplanted the following spring. Five outplantings, three in 1978 and two in 1979 were laid out in a randomized complete block design either in St. Williams or at Midhurst (44°27'N, 79°43'W) (Table 1). Four of the outplantings were designed in five blocks with 50 trees planted for each storage temperature for each lift and 100 trees for the spring lifted controls. One outplanting, the District Plant, was done by district crews in 1978 at St. Williams and was laid out in 10 blocks and 50 trees per treatment per block.

In the fall of the fourth year after outplanting, seedling survival and height for each plant were analysed using a two-way analysis of variance. Duncan's new multiple range test was used to determine significant differences among treatments.

A comparison of the field performance of all plants (Fig. 3) was constructed by calculating a mean value for the spring control and adjusting the aggregate height measurement (m/100 trees planted) for each lift by the amount that the controls for that plant deviated from the mean control value.

Results and Discussion

The 3+0 white pine nursery stock used in this study was large in comparison with Ontario standards (Armson and Sadreika 1979, Reese and Sadreika 1979). The mean oven dry weight was greater than 6.0 g and mean stem diameter larger than 0.45 cm. Mean height among lifts ranged from 18.9 to 23.8 cm in 1977-1978 and from 20.4 to 24.9 cm in 1978-1979.

Overwinter Storage and DHD

Overwinter stored stock from at least one fall lift in each of the outplantings performed in the field as well as or better than the spring control lift, confirming that white pine storage is a viable option available to nurserymen (Fig. 2). In early lifts (prior to lift 5 in 1978 and prior to lift 3 in 1979), cold stored stock survived significantly ($P < .01$) better than frozen stored stock after outplanting. The exception to this was in the 1979 Midhurst plant where severe mold killed virtually all the cold stored stock from lift 1 and a substantial portion from lift 2. Seedlings lifted later in the fall stored equally well at both storage temperatures. Maximum field performance was observed around 100 DHD although much variability existed

Table 1. Details for the five outplantings made with 3+0 white pine from St. Williams nursery in the spring of 1978 and 1979.

	1978			1979	
	St. Williams district plant	St. Williams research plant	Midhurst plant	St. Williams plant	Midhurst plant
Planting	Apr. 10, 12	Apr. 10, 12	May 1, 2	Apr. 11	Apr. 25
Controls lifted	Apr. 10	Apr. 10	Apr. 28	Apr. 11	Apr. 23
No. trees planted	8000	4000	8000	2500	2500
Soil type	sandy-loam	sandy-loam	clay loam	sandy-loam	clay loam
Land preparation	cultivation and discing	cultivation and discing	fallow	blade	fallow
Post planting treatment	simazine @ 2.7 kg/ha AE	none	cultivation	none	cultivation
Spacing	.6 × 1 m	.6 × 1 m	.3 × 1.5 m	2 × 2 m	1.5 × 1.5 m
Site	old farm	old farm	old farm	operational clear cut	old farm

at that point (Fig. 3). Lifts occurring after an accumulation of 125 DHD were more consistent in performance, and suggests a DHD requirement for St. Williams white pine of 125 which is lower than the 165 DHD requirement recommended for Midhurst (Mullin and Hutchison 1978b). This would indicate that the DHD requirement for safely lifting white pine for overwinter storage may be higher in more severe climates. The frost free period at St. Williams is similar to that at Orono nursery (43°55'N, 78°45'W) (Brown *et al.* 1968) and Orono white pine has a similar DHD requirement of 125.

There was evidence that field performance actually declined in stock that was lifted very late in the fall particularly in the cold stored stock (Fig. 3). In four of the five plants (Fig. 2), the cold stored stock from the last lift had significantly ($P < .05$) poorer survival than an earlier lift. This may suggest a "lifting zone" or optimum lifting period which may occur at various times in the fall, depending upon the climate of the nursery and seasonal environmental factors. Lifting as late as possible, as recommended by Williams and Rambo (1967), Nyland (1974a) and Mullin and Parker (1974) may coincide with the "lifting zone" on some occasions but might be too late on others.

The observed reduction in field performance of very late-lifted stock is not unique to white pine but has been observed in jack pine (Racey *et al.* 1983b) and white cedar (Racey *et al.* 1983a). The ever increasing nature of degree hardening days cannot detect or predict this downturn. Therefore, there is a demonstrated need to develop more direct measures of dormancy or stock quality. Measures that show some promise are electrical impedance (Glerum 1980) and the oscilloscope — square wave technique (Ferguson *et al.* 1975, Holbo *et al.* 1981).

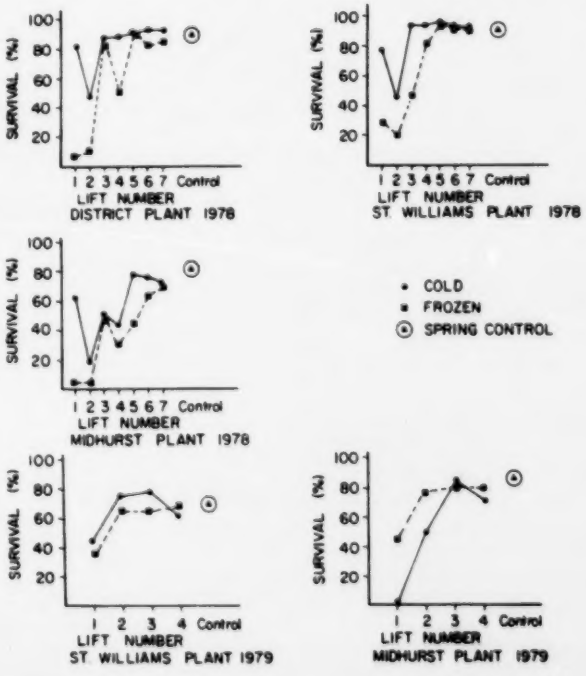

Figure 2. Percent survival after four growing seasons of cold and frozen overwinter stored and fresh lifted 3+0 white pine. Seven fall lifts were planted at three locations in 1978 and 4 lifts were planted at two locations in 1979.

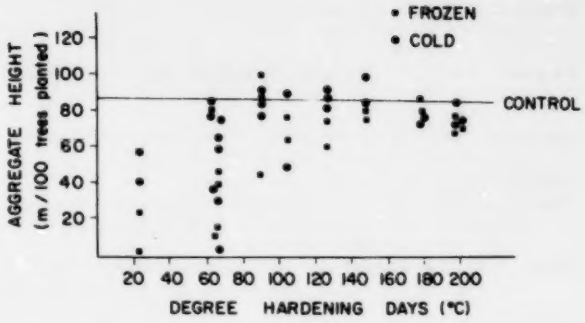

Figure 3. Aggregate height (m/100 trees planted) four years after outplanting of frozen and cold stored 3+0 white pine as a function of accumulated degree hardening days at time of lifting for storage. The results from each plant have been corrected to correspond to a common aggregate height for the fresh-lifted spring controls.

Cold vs. Frozen Storage

Cold storage generally gives better survival and field performance than frozen storage, particularly in lifts prior to the accumulation of 125 DHD. However, overwinter cold storage is not recommended because of the possibility of mold damage. In this study, numerous bags of trees from early lifts developed extensive mold while in cold storage, particularly lifts 1 and 2 of the 1979 Midhurst plant and lift 1 of the St. Williams plant in the same year. Mold can also cause extensive mortality in cold-stored white pine even if trees are lifted after the 125 DHD requirement is reached (Racey *et al.* 1984). Mold development is particularly dependent upon lifting time (Venn 1981), wetness of trees (Hocking 1971) and numerous pre-storage conditions (Venn 1980). Storage temperatures below 1°C (Hocking 1971, Nyland 1974b). discourage the growth of mold. Control of mold in overwinter storage by other means has led to variable results depending upon species and mold control treatment (Wilner and Vaartaja 1958, Hocking 1971 and Venn 1980).

Conclusions

White pine grown in southern Ontario have minimum degree hardening day requirements which range from 125 on the north shore of Lakes Erie and Ontario to 165 in the more central parts of Ontario, which are away from the modifying influences of the Great Lakes. We stress that DHD requirements for successful overwinter storage be developed for each nursery through an ongoing program of DHD measurement, stock quality monitoring and plantation performance assessment. Then, stock should be lifted shortly after the degree hardening day requirement has been met to avoid any reduction in performance from lifting too late. Frozen storage is more effective at controlling mold and should be selected over cold storage whenever possible.

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References

Armson, K.A. and V. Sadreika. 1979. Forest tree nursery soil management and related practices (metric edition). Ont. Min. Natur. Resour. Unnumbered. 179 p.

Brown, D.M., G.A. McKay and L.J. Chapman. 1968. The climate of southern Ontario. Can. Dept. Transport. Meteorological Branch. Climatological Studies No. 5. 50 p.

Ferguson, R.B., R.A. Ryker and E.D. Ballard. 1975. Portable oscilloscope technique for detecting dormancy in nursery stock. USDA For. Serv., Gen. Tech. Rep. INT-26. 16 p.

Glerum, C. 1980. Electrical impedance techniques in physiological studies. New Zealand J. For. Sci, 10: 196-207.

Hills, G.A. 1960. Regional site research. For. Chron. 36: 401-423.

Hocking, D. 1971. Effect and characteristics of pathogens on foliage and buds of cold-stored white spruce and lodgepole pine seedlings. Can. J. For. Res. 1: 208-215.

Holbo, H.R., C.A. Askren and R.K. Hermann. 1961. Does the oscilloscope technique reveal the dormancy status of Douglas-fir and Ponderosa pine? For. Sci. 27: 405-412.

Mullin, R.E. and R.E. Hutchison. 1978a. Lifting guides for frozen overwinter storage of black spruce at Swastika nursery. Ont. Min. Natur. Resourc. Nursery Note 55. 6 p.

Mullin, R.E. and R.E. Hutchison. 1978b. Fall lifting dates, overwinter storage, and white pine seedling performance. For. Chron 54: 261-264.

Mullin, R.E. and R.E. Hutchison. 1979. Seedbed treatments to aid in fall lifting for frozen overwinter storage. Ont. Min. Natur. Resourc. Nursery Note 64. 4 p.

Mullin, R.E. and J.S. Lucas. 1982. Overwinter storage tests of larch and tamarack. Ont. Min. Natur. Resour. Nursery Note 76. 6 p.

Mullin, R.E. and J.D. Parker. 1974. Bales versus polybags in cold and frozen overwinter storage of nursery stock. Can. J. For. Res. 4: 254-258.

Mullin, R.E. and J.D. Parker. 1976. Provisional guidelines for fall lifting for overwinter storage of nursery stock. For. Chron. 52: 1-4.

Nyland, R.D. 1974a. Fall lifting for over-winter cold storage of conifers. State Univ. New York, Appl. For. Res. Inst., Res. Rep. No. 22. 5 p.

Nyland, R.D. 1974b. Sub-freezing temperatures control storage moulding. State Univ. New York. Appl. For. Res. Inst., Res. Note No. 11. 3 p.

Racey, G.D. and R.E. Hutchison. 1983. Overwinter storage of scotch pine at St. Williams Nursery. Ont. Min. Natur. Resour. Nursery Note 87. 4 p.

Racey, G.D., C. Glerum and R.E. Hutchison. 1983a. Cold and frozen overwinter storage of white cedar. Ont. Min. Natur. Resourc. Nursery Note 90. 6 p.

Racey, G.D., C. Glerum and R.E. Hutchison. 1983b. Effects of packaging on field performance of fall and spring lifted jack pine at Swastika nursery. Ont. Min. Natur. Resour. Nursery Note 88. 5 p.

Racey, G.D., R.E. Hutchison and C. Glerum. 1984. Effect of extended cold storage after overwinter frozen storage of white pine and white spruce. Ont. Min. Natur. Resour. Nursery Note 105. 5 p.

Reese, K.H. and V. Sadreika. 1979. Description of bare root shipping stock and cull stock. Ont. Min. Natur. Resour. 36 p.

Venn, K. 1980. Winter vigour in *Picea abies* (L.) Karst. VII. Development of injury to seedlings during overwinter cold storage. A literature review. Meddi Norsk Inst. Skogforsk. 35: 483-530.

Venn, K. 1981. Winter vigour in *Picea abies* (L.) Karst. VII. Mouldiness and injury to seedlings during overwinter cold storage. Meddi Norsk Inst. Skogforsk. 36: 1-28.

Williams, R.D. and R. Rambo. 1967. Overwinter cold storage of red and white pine transplants successful in northern Indiana. USDA For. Serv. Tree Planters' Notes 18: 21-23.

Wilner, J. and O. Vaartaja. 1958. Prevention of injury to tree seedlings during cellar storage. For. Chron. 34: 132-138.